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Fifteen-year survival of endoscopic anterior cruciate ligament reconstruction in patients aged 18 years and younger

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1 **15 Year Survival of Endoscopic Anterior Cruciate Ligament Reconstruction in Patients Aged**
2 **18 and Under**

3 **ABSTRACT**

4 **Background.** Within the young population, the literature examining the short term survival and the variables
5 contributing to ACL injury after primary ACL reconstruction is limited. The long term evidence for the same is
6 non-existent.

7 **Purpose:** To determine the long term survival of the ACL graft and the CACL after primary reconstruction in
8 those aged 18 years and under, and to identify the factors that increase the odds of subsequent ACL injury.

9 **Study Design:** Case series; Level of evidence, 4.

10 **Methods:** Patients having undergone primary ACL reconstruction at age 18 or less between 1993 and 1998,
11 included in a prospective database by a single surgeon were considered. Single-incision endoscopic ACL
12 reconstruction was performed with either autologous bone-patellar tendon-bone graft (BPTB) or hamstring
13 tendon graft (HT). At a minimum of 15 years after ACL reconstruction patients completed a subjective
14 questionnaire regarding current symptoms, further ACL injury, family history of ACL and level of activity.

15 **Results:** 288 juveniles, aged 13-18 years, met the inclusion criteria of which 242 (84%) were reviewed at a
16 mean of 16.5 years after ACL reconstruction. 75 (31%) patients sustained a further ACL injury of which 27
17 (11.2%) suffered an ACL graft rupture, 33 suffered a CACL injury (13.6%) and 15 sustained BOTH an ACL graft
18 and a CACL rupture (6.2%) over 15 years. Survival of the ACL graft was 95%, 92%, 88%, 85% and 83% at 1, 2, 5,
19 10 and 15 years, respectively. Survival of the CACL was 99%, 98%, 90%, 83% and 81%, respectively. Survival of
20 the ACL graft was less favourable in those with a positive family history (69% versus 90%, HR 3.6, p = .001).
21 Survival of the CACL was less favourable in males than in females (75% versus 88%, HR 2.1, p = .03) and those
22 that returned to competitive team ball sports (78% versus 89%, HR 2.3, p=0.05).

23 **Conclusion:** After ACL reconstruction in those aged 18 years or less, further ACL injury occurred to 1 in 3 over
24 15 years. The 15 year survival of the ACL graft was 83% and 15 year survival of the CACL was 81%. Family
25 history of ACL rupture significantly increased the hazard for ACL graft rupture and CACL injury was more

26 common in males and those who return to team ball sports. High subjective scores and continued
27 participation in sports were maintained over the long term after ACL reconstruction in the juvenile population.

28 **Keywords:** ACL reconstruction; graft rupture; juvenile; contralateral ACL; survivorship; long-term.

29 **What is known about the subject:** It has been demonstrated that younger populations are more likely to have
30 a second ACL injury after ACL reconstruction, compared to adults. However the data is limited and the
31 incidence of reinjury over the longer term (>5years) has not been reported in the juvenile population

32 **What this study adds to existing knowledge:** This study documents the long term incidence of ACL graft and
33 contralateral ACL injury after reconstruction in a large population of juveniles.

34

35 INTRODUCTION

36 The incidence of anterior cruciate ligament injury in children and adolescents is increasing, especially in those
37 who practice competitive sports^{4,7,9,12}, reportedly accounting for 0.5-3% of all ACL injuries.¹⁵ The increase in
38 the rate of ACL injuries in the younger population is likely multifactorial and is a reflection on the increased
39 awareness of this injury within this population, the higher rates of participation in high demand sports at an
40 earlier age and improved rates of diagnosis as a result of better imaging and diagnostic tools.

41 As with their adult counterparts, the absence of ligamentous stability within the child's knee predisposes them
42 to the risk of further meniscal and chondral injuries, potentially leading to early degenerative changes. As
43 such, the current literature identifies a present trend towards ACL reconstruction as the preferred treatment
44 option for ACL injuries in the young, especially given the poor outcomes associated with non-operative
45 treatment.^{5,8,26,30} This trend towards surgical management of ACL rupture in children is reflected in the
46 Australian population with the number of ACL reconstructions in children younger than 15 years of age
47 increasing by almost 4 times over the last 15 years.¹⁹

48 Even more devastating than a primary ACL injury is the increased risk of further injury to either the ACL graft or
49 the native ACL in the contralateral knee. Further ACL injury after primary ACL reconstruction is a well
50 recognised complication, especially in the young, with several studies reporting a higher incidence of further
51 ACL injury in this population compared with their older equivalents.^{1,2,14,16,17,27,29,31,33} In their Danish ACL
52 registry study, Lind reported an 8.7% risk of revision ACL reconstruction over a 5 year period in patient's
53 younger than 20 years of age.¹⁴ Similarly, in a series of 119 patients in this same age group, Magnussen
54 reported a revision rate of 14.3% at a minimum of 6 months post primary reconstruction.¹⁶ Shelbourne
55 identified a 17% increased risk of further ACL injury after reconstruction in children aged under 18 over 5
56 years²⁹ and more recently, in their series of 110 young people aged <20 years, Webster reported an incidence
57 of subsequent ACL injury of 29% at a minimum of 3 years post primary ACL reconstruction.³³

58 In the current body of evidence surrounding repeat ACL injury in the younger population, the long term
59 incidence is inadequately described. Therefore, the aim of this study was to determine the long term
60 incidence of ACL graft and CACL rupture and to identify the factors that affect ACL graft and CACL survival in a
61 population aged 18 years or less at a minimum of 15 years post primary ACL reconstruction.

62 MATERIALS AND METHODS

63 Patient Selection

64 Subjects included in the study were identified from a prospective database of knee surgery and had undergone
65 a primary ACL reconstruction performed by a single surgeon [REDACTED] in a single unit between the years of 1993
66 and 1998 and were aged ≤ 18 years at the time of surgery. The exclusion criteria were: (1) patients who had
67 had a previous CACL rupture, (2) those not wishing to be involved in a research project, (3) those who died (of
68 unrelated causes) during the study period.

69 Patient demographics were recorded in a prospective database and included information on the side of
70 surgery, age, gender, graft type, graft size and meniscal or articular cartilage injury seen at the time of surgery.

71 Participants were sent an information sheet via post or email detailing the project and inviting them to
72 participate. Subjective outcome data was obtained by contacting all subjects meeting the inclusion criteria via
73 telephone or email at a minimum of 15 years following the surgery. Those willing to participate in the study
74 completed a telephone interview or written questionnaire, which was returned to us via post or email. A
75 research physiotherapist or an honours medical student, both of whom had not been involved in the original
76 surgery, performed the telephone questionnaires.

77 Ethical approval was sought and granted, after submission of the study protocol, by a local independent
78 human ethics committee ([REDACTED]).

79 Subjective Evaluation

80 The questionnaire completed by patients included the full International Knee Documentation Committee
81 (IKDC) subjective knee evaluation form in addition to questions relating to family history of ACL rupture,
82 subsequent injury and/or surgery to either knee, whether return to pre-injury level of sport was achieved and
83 the current level of activity of the subject. Family history was considered to be positive if the patient had a
84 first degree relative (parents or siblings) who had sustained an ACL rupture at any time. A return to IKDC level
85 5 sports was defined as regular participation in very strenuous activities involving cutting or pivoting type
86 manoeuvres, as in basketball or soccer.

87 All patients who reported further injury to either knee that had not previously been documented were invited
88 to attend for further review. Graft rupture or CACL rupture was considered to have occurred only if: (1) the
89 patient had had confirmed further knee reconstructive surgery (graft rupture) or primary reconstruction
90 (CACL) performed in our unit or by another orthopaedic surgeon; (2) had clinical examination and/or an MRI
91 scan reviewed by our unit to confirm ACL deficiency or (3) if the patient had reported another injury
92 characteristic of an ACL tear to either knee and they had not been reviewed by us. For this last group we
93 assumed a graft rupture or CACL rupture for the purposes of the survival analysis as a worse case scenario.

94 Operative Technique

95 ACL reconstruction was performed by the senior author in all cases using a technique previously described.³
96 This was a single-incision, endoscopic technique with anteromedial portal femoral tunnel drilling. Two-types of
97 grafts were used during this time period: autologous four-strand hamstring tendon (HT) and autologous bone-
98 patellar tendon-bone (BPTB). There was no randomization involved in graft type selection. From the beginning
99 of 1993 BPTB autograft was routinely used. In October 1993, use of HT autograft was commenced, and after
100 April 1994, HT graft was used exclusively. Operative techniques for both graft types were identical. Fixation in
101 both graft-types was achieved using 7×25mm titanium interference screws (RCI; Smith & Nephew, Mansfield,
102 MA) in both the femoral and tibial tunnels. Patients were allowed to fully weight-bear immediately and no
103 brace was used. Early accelerated rehabilitation was then commenced. Patients were allowed to return to
104 competitive sports involving pivoting and sidestepping activity at 6-9 months according to objective
105 assessment of whether the rehabilitation goals had been met.

106 Statistical Analysis

107 Statistical analysis was performed using SPSS software. Statistical significance was set at $p < 0.05$. The
108 probability of failure was estimated as a function of time using the Kaplan-Meier (K-M) survival method.
109 Survival tables at 1, 2, 5, 10 and 15 years were collated. Comparisons of survival curves were made with
110 univariate Cox proportional hazards. Factors that were significant, or nearly significant ($p < 0.10$) on univariate
111 analysis were entered into a multivariate Cox regression analysis. Factors were then eliminated one at a time
112 in a stepwise fashion, until only the independent significant factors remained.

113

114 **RESULTS**

115 Between January 1993 and December 1998, 2835 patients underwent primary ACL reconstruction. Of these,
116 351 were aged 18 or less at the time of surgery. The following patients were excluded: (1) those with a
117 previous contralateral ACL injury (n=57); (2) those who refused to participate in a research database (n=4); (3)
118 those who died (of unrelated causes during the study period) (n=2). This left 288 patients in the study group of
119 which 242 (84%) completed the subjective questionnaire at a minimum of 15 years after surgery. The
120 participant flow is shown in Figure 1. 242 patients completed the questionnaire at a mean of 16 years and 6
121 months (range, 15 years, 0 months – 20 years, 6 months) from surgery. Of the 242 patients, 167 (69%) had no
122 subsequent ACL injuries and 75 (31%) sustained a further ACL injury. Of the 75 with further ACL injuries, 27
123 (11.2%) sustained an ACL graft rupture, 33 sustained a contralateral ACL injury (13.6%) and 15 sustained BOTH
124 an ACL graft and a contralateral ACL rupture (6.2%).

125 Demographics (n=242)

126 There were 104 (43%) females and 138 (57%) males. The mean age at surgery was 16 years (range, 13-18).
127 There were 109 left-sided and 133 right-sided reconstructions. Surgery was performed in the acute phase
128 (within 3 weeks of injury) in 7 patients (3%), in the sub-acute phase (3-12 weeks) in 166 patients (69%) and in
129 the chronic phase (> 12 weeks) in 69 patients (28%). BPTB autograft was used in 48 cases (20%) and HT
130 autograft in 194 cases (80%). The mean diameter of the HT graft was 7.1mm (range 6-9mm) and the mean
131 diameter of the BTPB graft was 9.7mm(range 9-11mm) ($p=.001$, Mann-Whitney U Test).

132 152 patients (63%) had an ACL reconstruction only and no meniscal debridement. 26 patients (11%) required
133 partial or total excision of the medial meniscus performed at the time of the reconstruction and 52 patients
134 (21%) required partial or total excision of the lateral meniscus. Meniscal sutures were used in 10 patients in
135 the medial meniscus and 10 patients in the lateral meniscus.

136 The primary ACL rupture was most commonly sustained in the sports of rugby and soccer, which accounted for
137 48% of injuries (see Figure 2).

138

139 Subjective Outcomes

140 Of the 242 patients who completed the questionnaire at 15 years, 168 (69%) reported returning to their
141 preinjury level of activity. Of the 74 who did not return to the preinjury level of activity, 30 (12%) reported it
142 was due to their operated knee and the remaining 44 patients (18%) cited other reasons.

143

144 The mean overall IKDC score for patients with intact ACL grafts (n = 200) at 15 years was 89 (range, 30-100).

145 There was no significant difference between the mean subjective IKDC score between males and females (87 v
146 88, p=.415), or hamstring and patellar tendon grafts (88 v 87, p=.746). At 15 year review, 131 (66%) were
147 participating regularly in IKDC Level 4-5 sports. There was no significant difference between the proportion of
148 those participating in Level 4-5 sports between males and females (84% v 84%, p=.99), or hamstring and
149 patellar tendon grafts (85 v 79, p=.377).

150

151 ACL Graft Rupture

152 ACL graft rupture occurred in 42 patients (17%) over 15 years, equating to an annualised graft injury rate of
153 1.1% per year. The ACL graft rupture was confirmed at the time of revision ACL surgery in 37 patients and by
154 MRI and clinical examination in 5 patients. Patients who reported characteristics of rupture in the
155 questionnaire and had not undergone further reconstructive surgery were examined in our unit. Kaplan-Meier
156 survival analysis for graft rupture is illustrated in Figure 3. ACL graft survival was 95%, 92%, 88%, 85%, 83% at
157 1, 2, 5, 10 and 15 years after reconstruction. The results of univariate analysis are shown in Table 1. A positive
158 family history of ACL injury increased the hazard ratio of further ACL graft injury by a factor of 3.6 (p=.001).
159 Factors that are significant, or nearly significant (p <.10) on univariate analysis (family history, graft type and
160 gender) were entered into a multivariate Cox regression analysis. Factors were then eliminated one at a time
161 in a stepwise fashion, until only the independent significant factors remained. On stepwise multiple regression
162 analysis, only a positive family history remained a significant hazard for poorer ACL graft survival with a hazard
163 ratio of 3.6 (95% CI 2.0-6.7, p < .001). The Kaplan-Meier chart of ACL graft survival and family history of ACL
164 injury is shown in Figure 4.

165 Contralateral ACL Injury

166 48 patients (20%) were known to have sustained a CACL rupture during the study period, which equates to an
167 annualized rupture rate of 1.3% per year. The incidence of reconstructed ACL injury (17%) was not
168 significantly different from the incidence of CACL injury (20%) after reconstruction ($p=.72$). CACL injury was
169 confirmed at the time of CACL reconstruction in 45 patients, and clinical examination and MRI in our unit in 3
170 patients. CACL injury occurred at a mean of 71 months (range, 8-202) from ACL reconstruction. Kaplan-Meier
171 survival analysis for CACL rupture is illustrated in Figure 5. CACL survival was 99%, 98%, 90%, 83%, 81% at 1, 2,
172 5, 10 and 15 years respectively, after reconstruction. The results of univariate analysis are shown in Table 2.
173 Male gender increased the hazard ratio of CACL injury by a factor of 2.1 ($p=.03$). Factors that were significant,
174 or nearly significant ($p < .10$) on univariate analysis (graft type, gender and return to Level 5 sport) were
175 entered into a multivariate Cox regression analysis. Factors were then eliminated one at a time in a stepwise
176 fashion, until only the independent significant factors remained. On stepwise multiple regression analysis,
177 poorer CACL survival was associated with male gender with a hazard ratio of 2.1 (95% CI 1.1-3.9, $p = .03$), and
178 return to Level 5 sport with a hazard ratio of 2.3 (95% CI 1.0-5.4, $p = .05$). Graft type did not remain a
179 significant factor on multiple regression analysis. The Kaplan-Meier curves for these significant factors are
180 shown in Figures 6 and 7.

181

182 In those who received the hamstring tendon graft there was a trend to a higher incidence of ACL graft rupture
183 at 15 years, compared to those who received a patellar tendon graft ($p=.06$). However, those who received a
184 patellar tendon graft displayed a trend to a higher incidence of contralateral ACL injury ($p=.08$) (Table 3).

185

186 **DISCUSSION**

187 After a minimum of 15 years post primary ACL reconstruction, 69% of adolescents returned to their pre-injury
188 level of activity, however, this was at a significant cost. Approximately one third of this population suffered a
189 further ACL injury during the study period, with an incidence of 20% in the contralateral knee and 17% in the
190 reconstructed knee. Further ACL injury in the adolescent cohort is relatively common with several factors
191 being implicated in contributing to this increased risk.

192

193 The ACL graft survival 15 years after a primary ACL reconstruction in the adolescent population is significantly
194 reduced in the presence of a positive family history. Those with a first degree relative with a history of ACL
195 injury are almost 4 times more likely to suffer an ACL graft rupture than their peers with no family history. In
196 this study, an intact ACL graft was seen in 90% of ACL grafts belonging to a child with no family history, and
197 only 69% of ACL grafts in those with a positive family history. This finding is consistent with other published
198 series^{2, 6, 33} and although it is likely multifactorial, the reason behind this finding remains unclear. A
199 preponderance of collagen gene defects described in the literature has been associated with an increase in the
200 risk of ACL rupture.^{24, 25} Type I and type V collagen are the major structural constituents of ligaments,
201 therefore, variants in their associated genes, COL1A1 and COL5A1 respectively, have been reported to render
202 the ACL vulnerable to rupture.^{24, 25} More recently, in their 2014 study, Mannion¹⁸ identified certain
203 polymorphisms of proteoglycan genes that may account for an increase in susceptibility of ACL injury. Higher
204 posterior tibial slopes are known to significantly increase the risk of further ACL injury after reconstruction³²,
205 and it has been reported that posterior tibial slope is increased in those with a positive family history of ACL
206 injury, compared to controls.¹⁰ In addition to genetics, environment may also play a role in the relationship
207 between family history and increased ACL graft rupture. An individual who is part of a family with a 'sporting'
208 or 'active' culture will inherently be at risk of further ACL injury due to a likely increased exposure to physical
209 activity. It would be expected that these factors would also increase the risk of CACL injury in those with a
210 family history of ACL rupture, however, in this series, this was not the case.

211

212 Males and those who return to their pre-injury level of sport were found to have an increased risk of CACL
213 rupture by a factor of 2.1 ($p=.03$) and 2.3 ($p=.05$) respectively. It is obvious that a return to sport, especially
214 those that involve cutting and pivoting type manoeuvres, poses a potential risk to both the ACL graft and the
215 native CACL. In this study, a return to sport significantly increased the odds of a CACL rupture, but not an ACL
216 graft rupture. This may simply be due to the fact that the CACL is more vulnerable on return to sport after an
217 ACL reconstruction due to the patient subconsciously protecting the reconstructed knee thereby increasing the
218 stress on the contralateral knee.

219

220 Gender as an independent risk factor for CACL injury after primary ligament reconstruction remains
221 controversial in the literature. A number of authors report no significant difference between males and
222 females^{11, 13, 23, 28, 33} while others report an increase in the incidence of CACL rupture in females^{17, 22, 29} after ACL
223 reconstruction. This result could be explained by a greater proportion of males returned to sports that were
224 considered higher risk in terms of ACL rupture than females. Figure 2 illustrates that over 80% of subjects
225 originally ruptured their ACL playing team ball sports (e.g. rugby, soccer, netball, touch football and hockey).
226 91% of males and 69% of females ($p=.001$) suffered their primary ACL rupture while playing these sports.
227 Therefore, despite no significant difference in the overall number of males and females returning to sport
228 (84% vs 84% respectively) after ACL reconstruction, it is possible that more males returned to one of these
229 higher risk activities rendering their CACL vulnerable.

230

231 A large proportion of ACL graft ruptures occurred within the first two years of ACL reconstruction, as
232 illustrated by the slope of the survival curve in Figure 3. We found one third of the total number of ACL graft
233 ruptures to occur within one year of primary reconstructive surgery, an incidence of 5%. At the time of initial
234 ACL reconstruction, it was standard practice to recommended that patients refrain from returning to vigorous
235 sport for 6-9 months post reconstruction. Since those days, reports have suggested that the maturation
236 process of the ACL graft continues for at least 12 months after reconstruction with neuromuscular
237 performance of the knee being hindered for this time also.^{21, 28} In fact, in their 2000 paper, Wojtys³⁵ noted
238 ongoing neuromuscular deficits up to 18 months post ACL reconstruction. With this information and the

239 knowledge that the addition of specific neuromuscular and plyometric training into current ACL rehabilitation
240 programs reduces the risk of further ACL injury,^{20, 34} we recommend delaying a return to vigorous sport until a
241 minimum of 12 months post-reconstruction.

242

243 We examined a number of variables to assess their influence on further ACL injury in this young population.
244 Age less than 14 years at the time of ACL reconstruction did not significantly effect 15 year survival ($p=.21$), but
245 this may reflect the low sample size of the very young cohort ($n=23$). Very young age may have more of a
246 negative influence in the first 2 years when the incidence of graft rupture was 17% in the <14 year population,
247 versus 7% in the >14 year population. Use of the hamstring tendon graft displayed a trend towards higher
248 rates of ACL graft injury ($p=.06$), but lower rates of contralateral injury ($p=.08$), compared to the patellar
249 tendon graft. Overall, 67% of the patellar tendon patients and 70% of the hamstring tendon patients had not
250 sustained any further ACL injuries at 15 years ($p=.912$). Graft selection may influence which knee sustains
251 further injury, but the overall rate of injury appears to be equivalent with hamstring and patellar tendon grafts
252 in the young population.

253

254 An intrinsic weakness of this study needs to be recognised. Due to the design of the study, there was an
255 inherent risk that the incidence of ACL graft and CACL rupture was incorrectly reported. At some stage during
256 the follow up period, patients may have sustained a subclinical ACL injury and not noticed instability due to a
257 reduction in their activity level. In an attempt to minimise this issue, patients who reported further injury to
258 either knee during the study period via the subjective assessment were invited to attend our clinic for further
259 assessment regarding the presence or absence of a subsequent ACL injury. It is unlikely that the incidence of
260 further ACL injury was over-reported given the fact that further ACL injury was either confirmed at the time of
261 revision (ACL graft) or primary (CACL) surgery or confirmed via clinical and/or radiological means.

262

263 Anterior cruciate ligament reconstruction in young people is a successful procedure resulting in 69% of
264 patients returning to their preinjury level of sport and 66% of patients continuing to participate in regular

265 physical activity after a minimum of 15 years post primary ACL reconstruction. Despite this success, the risk of
266 further ACL injury in this patient cohort is common. One third of patients aged 18 years and under who
267 undergo a primary ACL reconstruction are at risk of further ACL rupture to either knee with no statistical
268 difference in the risk between ACL graft and CACL rupture. Patients with a positive family history are four
269 times as likely to rupture their reconstructed ACL, an injury likely to occur within the first 2 years after primary
270 ACL reconstruction. Young male patients and those who return to cutting or pivoting sports are twice as likely
271 to rupture their contralateral ACL when compared to females and those who refrained from sport.

272

273 Orthopaedic surgeons need to ensure they appropriately counsel their younger patients and their parents on
274 the markedly increased risk of further ACL injury, especially in males with a positive family history who wish to
275 return to their desired sport of choice. Young patients and their families need to understand the risk of
276 returning to sport prematurely and should be strongly advised to refrain from this for at least 12 months post
277 ACL reconstruction.

278

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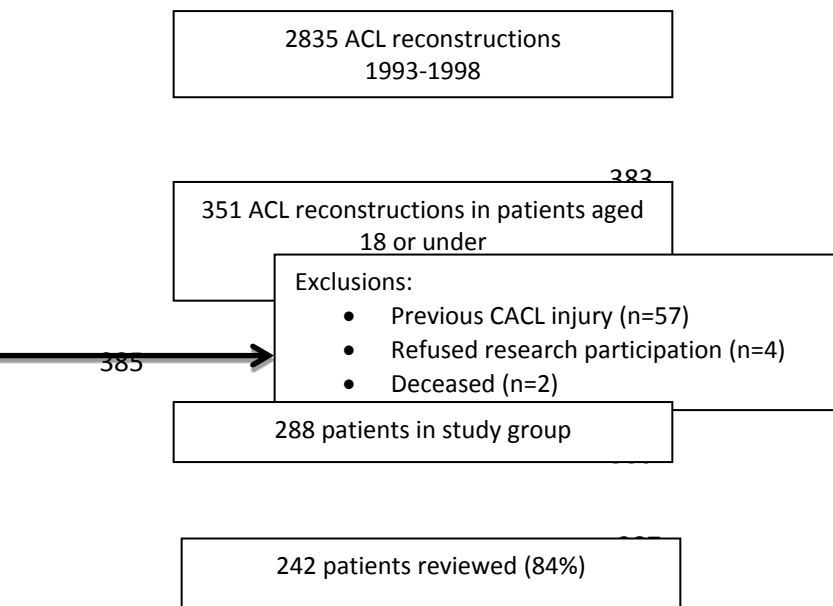
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379 **FIGURES**

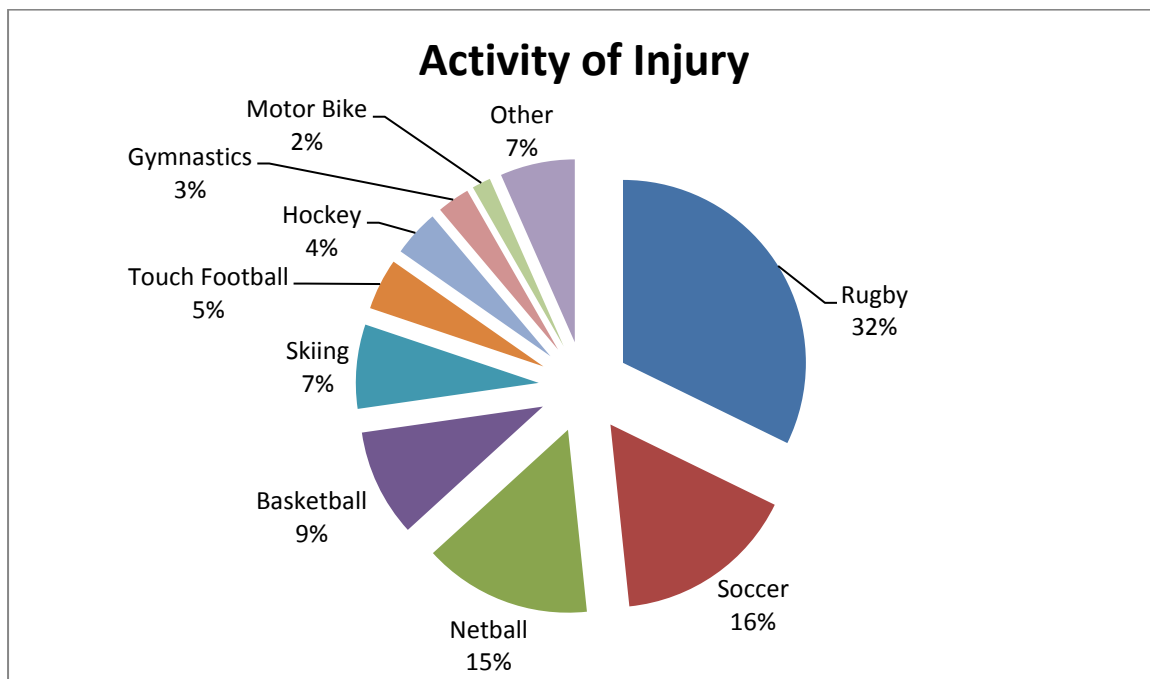
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389 **Figure 1:** Participant Flow Chart

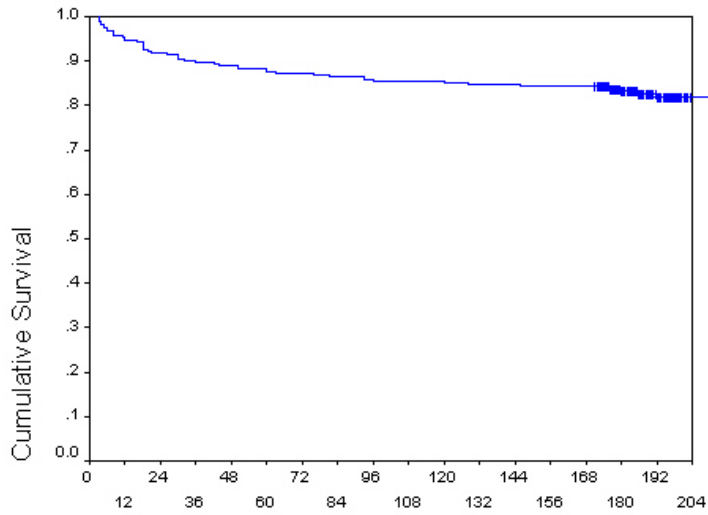
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392 **Figure 2:** Activity responsible for the initial ACL injury.

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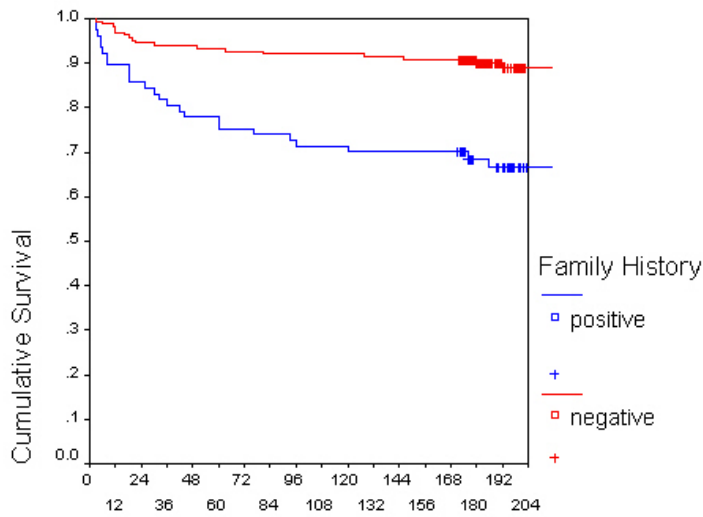
ACL graft survival (months)

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395 **Figure 3:** Kaplan-Meier curve for ACL graft survival.

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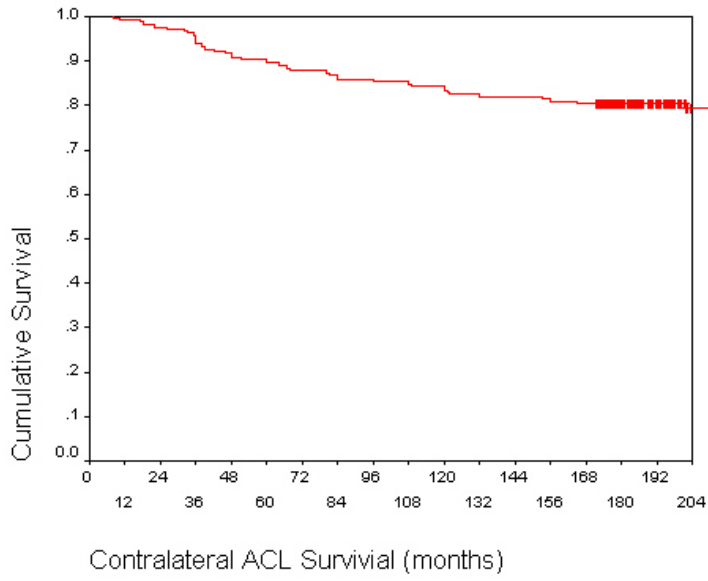


ACL graft survival (months)

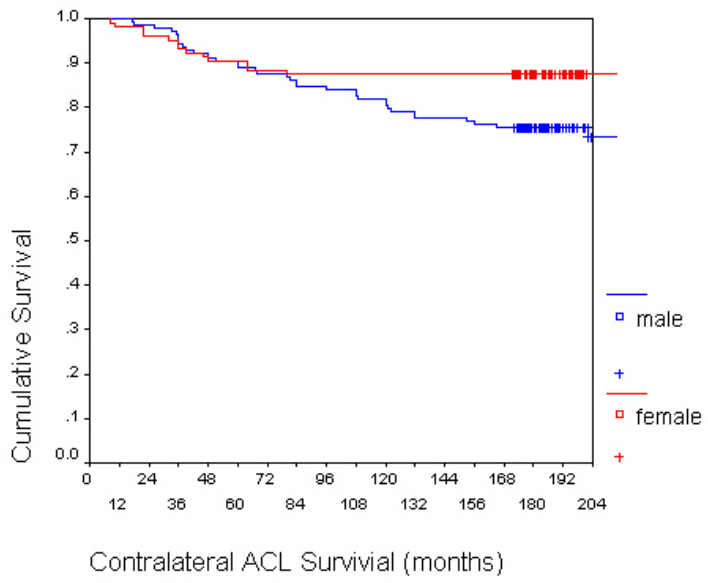
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399 **Figure 4:** Kaplan-Meier curve of ACL graft survival for those with and without a positive family history of ACL
 400 injury (defined as first degree relative with known ACL injury).

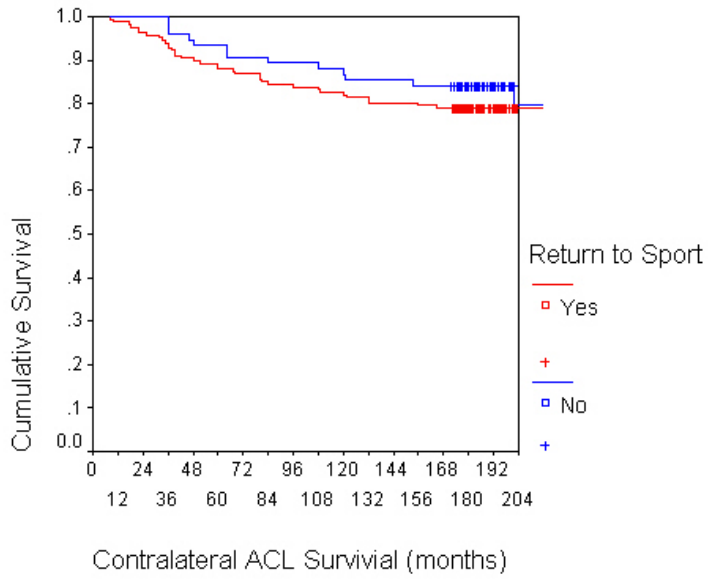
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403 **Figure 5:** Kaplan-Meier curve of contralateral ACL survival
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406 **Figure 6:** Kaplan-Meier curve of contralateral ACL survival for males and females.
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410 **Figure 7:** Kaplan-Meier curve of contralateral ACL survival for those who return to IKDC Level 5 Sports and
 411 those that did not.

412 TABLES

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415

TABLE 1
Survival of the ACL graft with univariate hazard ratios for the examined variables

Factor and Category	No	1 year survival	2 year survival	5 year survival	10 year survival	15 year survival	Hazard Ratio	95% CI	p-value
ALL	242	95	92	88	85	83			
Age at surgery									
14 years or less	23	90	83	78	78	73	1.7	0.7-1.4	0.21
> 14 years	219	97	93	90	86	84			
Graft									
Hamstring	194	96	90	86	83	81	2.7	0.9-7.5	0.06
Patellar	48	98	98	96	94	92			
Gender									
Male	138	93	91	86	82	80	1.8	0.9-3.4	0.09
Female	104	96	94	89	89	88			
Return to Level 5 sport									
Yes	185	94	90	85	82	81	2.0	0.8-4.6	0.13
No	57	100	96	93	93	91			
Family History of ACL injury									
Yes	77	90	86	75	70	69	3.6	2.0-6.7	0.001
No	165	97	95	93	92	90			
Graft Diameter									
7mm or less	115	100	92	88	85	83	1.1	0.6-2.0	0.747
> 7mm	127	94	91	87	85	83			

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TABLE 2
Survival of the contralateral ACL with univariate hazard ratios for the examined variables

Factor and Category	No	1 year survival	2 year survival	5 year survival	10 year survival	15 year survival	Hazard Ratio	95% CI	p-value
ALL	242	99	98	90	83	81			
Age at surgery									
14 years or less	23	100	100	91	87	78	1.1	0.4-2.8	0.83
> 14 years	219	99	97	90	83	81			
Graft									
Hamstring	194	99	98	92	87	83	1.8	0.9-3.3	0.08
Patellar	48	100	96	85	73	71			
Gender									
Male	138	100	99	91	80	75	2.1	1.1-3.9	0.03
Female	104	98	96	90	88	88			
Return to Level 5 sport									
Yes	185	99	97	88	81	78	2.3	1.0-5.5	0.05
No	57	100	100	95	93	89			
Family History of ACL injury									
Yes	77	100	99	88	84	81	1.0	0.5-1.9	0.94
No	165	99	97	90	83	81			

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TABLE 3
Incidence of ACL graft and CACL injury with HT or BPTB grafts

	Patellar tendon graft (n=48)	Hamstring tendon graft (n=194)	p-value
No further ACL injury	32 (67%)	135 (70%)	P=.912
ACL graft rupture	2 (4%)	25 (13%)	P=.06
Contralateral ACL rupture	12 (25%)	21 (11%)	P=.08
ACL graft and contralateral ACL injury	2 (4%)	13 (7%)	

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